FOOD FROM LAND II:
Non-Animal Protein

International Agricultural Research System

The Parliamentary and Scientific Committee
Presentation to Parliamentarians 30 November 1977

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It is difficult when considering anyone's dietary balance, particularly poor people living in the developing countries, to separate protein from overall caloric intake. The poorest people of Africa, Asia, Latin America and the Near East, probably derive between 70 and 95 percent of their calories and protein from cereal grains, grain legumes and root crops. At the outset it may therefore be useful to deal with the world food population equation macroscopically and then later deal with some of the specific issues relating to plant protein and finally what might be considered Canada's most useful role.

Based on estimated total world food production vs total demand (that is world population multiplied by average caloric requirement) the picture appears less bleak than a more detailed study would justify. During the past two decades, recognizing considerable fluctuations from year to year, recorded world food production has increased by roughly 69 percent; in developed countries by 65 percent, and in less developed countries by 75 percent. The trend rates of increase throughout the world were approximately 2.8% in food production and 2% in population. On this basis one might be led to believe that

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each of the 3.8 billion people alive in 1973 had 20% more food per capita than did the 2.7 billion who inhabited the earth during 1954. Unfortunately, because of markedly different rates of population growth between developed and less developed countries, average food per capita in the less developed countries (LDCs) increased by only 6% during the two decades. Among countries of black Africa the per capita rate of food production declined by roughly 3% during the 20 years in question.

Among developed countries the current average annual increase in population is close to 1%; among LDCs population is increasing by more than 2.5% per annum compared with roughly 2% per annum in 1950. Expressed slightly differently, the lands occupied by those classified as less developed accommodate two-thirds of the world's population and produce less than one-third of total farm output of food. If the present trend continues, by the end of the century the LDCs will represent more than three-quarters of the world's population and produce less than one-quarter of the world's food supply. A recent study of world production and demand for cereal grains, (International Food Policy Research Institute 1977) suggests that 10 years from now, if present trends continue, the developing countries will require to import 85 million tons of cereal grains in order to balance their indigenous production with demand. Clearly these global production and population statistics take little account of the wide disparity in availability resulting from uneven food distribution among different regions of the world,

among countries within regions, among communities within a country, among families within a community, and even among members of the same family. (Anyone who has observed the mealtime habits of poor rural African families who share a common pot have seen that it is the second youngest child, the one pushed from the breast by the most recent arrival, who fares worst at the family table. Its hands are too small to take from the common pot more than a few grains of rice or other cereal. If there is meat present, it is usually too tough for the small child to chew or digest. Also, as was the case in many countries during the depression years, it is often considered prudent to ensure that the bread winner takes priority at the meal table. It is a cause for mourning if a young child dies of malnutrition; but if the bread winner becomes sick or dies, the whole family economy collapses.)

The published statistics relevant to the population food demand equation tend to deal with food energy demand and supply and have little concern for essential nutrients with the possible exception of protein. Though cereals are an important source of protein, they are generally deficient in the essential amino acid lysine. Fortunately, food grain legumes, or pulses as they are known in the dry state, are comparatively rich in lysine and a diet composed of roughly two parts of cereal to one part of legume (i.e. an equal weight of protein from each) produces an almost perfect nutritional protein balance. Cereal grains and legumes provide on average more than 65% of the calories and 70% of the protein for all people

living in the LDCs. In Asia and the Far East, cereals and legumes furnish more than 72% of the calories and nearly 78% of the edible protein. Among the poorest rural and urban members of these communities, the reliance upon these subsistance grains both for energy and protein would be even higher. According to the best published information available (FAO Statistics), only in Latin America does the ratio of cereals to legume production approach the desirable 2:1 ratio. In South and Southeast Asia, because of the significant decline in per capita legume production over the last 25 years, the ratio of cereal to legume produced is of the order of 9:1. The production of legumes throughout most of the developing world has been steadily declining over the past two decades in relation both to cereal production and to population increase. During the past two decades in Asia, population increased by about 51%, total food production by 65%, but legume production by little more than 20%. Consequently, unless some significant changes occur, we may over the next 20 years be witness to a seriously inadequate food production in developing countries, both in terms of quantity and nutritional balance. In fact, subsistence food production will have to increase on average by no less than 4% per annum in the LDCs even if they are to maintain their present marginally adequate dietary standards. As a result of the world-wide energy crises, much more attention will have to be given to the cost of energy in terms of food production, processing, and distribution.

One at times encounters the somewhat naive view that great and rapid benefit would derive to the people of the LDCs if we were to accelerate the rate of transfer of our technologies. A recent study in the United States suggests that during 1970, 10.6 million kilogram calories were required to deliver his or her food to each consumer. Roughly 22% of this energy was used on the farm, 39% in food processing, and the remaining 39% in marketing, distributing, cooking and storage in the home. If the whole world were to adopt an equivalent food production and distribution system, it would absorb roughly 80% of the world's current energy production. Between 1945 and 1970 the output of maize in the United States increased by 240%, the labour input per acre decreased by 60% but the fossil energy input increased by 310%. Expressed slightly differently, in 1945 maize was yielding 3.7 calories per calorie of input but by 1970 the yield was 2.8 calories per calorie of input. According to another study in several countries of more than 100 food producing systems, it would appear that the relation between energy subsidy and productivity is far from linear. Dr. Slessor of Strathclude University presents evidence to suggest that prior to the use of machines and fossil fuels in crop production, the average return in terms of calories of digestible energy from each calorie of input was about four times what it is with present systems.

These statements should not be regarded as an argument against the use of synthetic fertilizers or other forms of converted fossil energy in our agricultural systems. Nevertheless, given the constraints of price and availability of fossil fuels over the last several years, it is evident that greater and more serious attention must be given to the efficiency of energy utilization, and in particular the utilization of nitrogen sources, including more effective use of farm waste, animal and possibly human waste and crop residues, either as soil conditioners or in animal feeds.

Though the stated near ideal ratio of cereal to legume in providing an acceptable protein nutritional balance is roughly 2:1, it must be emphasized that the nutritional quality of protein is highly variable according to source, a fact much emphasized in the recent writings concerning liquid protein diets. It may come as a surprise to some of the natural food propagandists that a great many of the seeds of edible subsistence plants, including cereals and legumes, contain substances that seriously interfere with the nutritional quality of protein and other essential nutrients. Sorghum, which covers a world acreage larger than maize, and is the primary subsistence crop for millions of the poorest people of the semi-arid tropics, in many varieties contain tannins that seriously reduce the digestibility of protein and the overall nutritional quality of the grain. Naturally occurring tannins have been used for centuries to convert animal hides to the insoluble, water-resistant form we know as leather.

It is possible that the tannins in sorghum similarly render cereal proteins insoluble and therefore nutritionally unavailable. Consequently, one must be cautious in accepting global statistics of grain production as a true measure of what is available to meet man's nutritional requirements. The crude statistics of production from such agencies as FAO suggest that there is protein sufficient to meet the nutritional needs of the developing countries but such may not be the case. In the first place, it is not improbable that the statistics overestimate the protein content of the crops, it is almost certain that they do not make adequate allowance for variations in nutritional quality and availability of the protein, and they take little if any account of significant post-harvest losses and variability in distribution among income groups and other categories of the developing countries societies.

It is gratifying to observe an increasing interest among scientists in what might be called the post-harvest system: the chain of events that begins with harvest and ends in the consumer's stomach. However, up to the time of writing it is probably true to say that the post-harvest system has received more attention in debate than in action. In relation to protein, it should be mentioned that many insects and microorganisms preferentially attack the high protein fractions of stored grains, consequently the proportional degree of nutritional damage may far exceed the overall weight loss suffered.

It is probable that over the foreseeable future the poorest people of the LDCs will continue to rely upon edible plants such as cereals, legumes and roots to satisfy their food requirements. Consequently, the continued decline in legume production must be a matter of considerable concern for all men of good intentions. Low legume yields reflect in large part the comparative lack of attention they have received from plant breeders. At present, the average global yields of the major cereals, wheat and rice, that have received a good deal of attention, are of the order of 2 t/ha. Most food legumes on the other hand, with the exception of soybeans yield considerably less than half a ton per hectare throughout the developing countries. Consequently, on the small 1 to 2 hectare farms of many of the developing countries where land is a primary constraint, cereals will be obviously more attractive to the farmer than a crop of legumes. Research that the International Development Research Centre is supporting in Asia and the Near East clearly indicates the potential of most major legumes for significantly higher yields but what is required is greater support for research dedicated to their improvement and to the demonstration of better agronomic practices. Legumes carry the advantage of being able to fix much of their own nitrogen from the air and therefore they are less dependent upon synthetic fertilizers. This character can benefit other crops and in research IDRC is supporting in Africa, Asia and Latin America, cereals such as maize, sorghum and millet when intercropped with food legumes, produce a higher return both

to land, investment and labour than when either crop is grown in pure stand. For about four years IDRC has been supporting what is proving to be a very productive program in the Near East involving some 16 countries from Pakistan in the East to Morocco in the West, and from Turkey in the North to Ethiopia in the South, in which groups of young legume breeders are brought to a central research station in the Lebanon and Syria where they learn in the field and through demonstrations, improved legume production - they select seed, plant and supervise their crop right through the whole growing cycle until harvest, evaluation and reselection of the best cultivars - then take back to their own countries seed best suited to their own environments. Their research continues as a cooperative network supported by the central research staff. This kind of regional cooperative program promises significant improvement in legume productivity and quality within the foreseeable future. In addition, IDRC is supporting legume research at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) with its headquarters at Hyderabad India where cultivars superior in yield capability and protein content are being identified.

Another approach through research is to improve the nutritional quality of cereal protein. As stated above, cereals as a class tend to be deficient in an essential amino acid, a component of the protein, the balance of which determines the nutritional value of the protein. In a project that IDRC has supported in Ethiopia for several years, two naturally occurring wild cultivars have been discovered that are

naturally much higher in lysine than all of those previously known and a major program is now underway to combine this high lysine superior nutritional quality with other desirable characteristics such as a high yield and disease resistance capability.

IDRC and CIDA have cooperated in supporting research with similar objectives at the International Maize and Wheat Improvement Centre (CIMMYT) in Mexico in cooperation with the Universities of Manitoba and Guelph. This project was designed to exploit the full potential of the first man-made cereal hybrid, triticale, which is a cross between wheat and rye and combines many of the desirable characteristics of each. The attractiveness of wheat as a food cereal requires no elaboration; rye on the other hand is much more tolerant than wheat to light, sandy, acid and aluminum soils, and to low night temperatures. In addition, some rye varieties are significantly higher in lysine than the average for wheat. The triticale research program can now demonstrate varieties that will outyield wheat under a wide variety of conditions including marginal soils, high altitudes such as in the highlands of Ethiopia, Kenya and the foothills of the Himalayas, between 6,000 and 10,000 feet, and with protein contents at least 1% higher than the overall average for wheat and in some cases with a lysine content equivalent to high lysine maize.

Clearly then, through adequately financed, competent applied research, significant improvement can be made both in the total production and in the nutritional quality of edible plant proteins.

One might anticipcate the reasonable question "How long will it take for these genetic and agronomic improvements to find their way into farmers' fields and the results into consumers' stomachs?". Though it is difficult to give a precise answer, it is the belief of my colleagues in IDRC that we are gradually and effectively reducing the lead time mainly by bringing the farmer into the research process at an earlier stage than was common in the past. It is becoming clear to us that the traditional pattern of research followed by extension and demonstration to the farmer of the finished final product is too attenuated and uncertain a process. Consequently in much of the research we support, we encourage that part of it be carried out in farmers' fields, first to determine from the beginning what are the farmer's primary constraints, their attitudes not only to technology but more important to risk, and therefore what new and improved technologies are likely to receive most rapid acceptance and adoption. We are also trying to encourage considerably more research among consumers in developing countries. One could present a weary litany of technological advances that have pursued no further than a paper to a learned society simply because the product was unacceptable or unusable by the consumer. In Africa therefore we have been encouraging a group of home economists to make a detailed

study in their countries of what women expect to find when they go to the village market place to buy legumes. For how long and in what manner are they cooked? What is the consumer's concept of quality both in the original and the cooked product? The outcome of one study we supported indicated that among many West African rural women, ten hours of the day are absorbed in collecting firewood, carrying water, and grinding cereals and legumes. Clearly legumes that require long cooking and whose properties are unconducive to milling by the simple tools available won't be accepted no matter how high their yield or their protein content. We have therefore been bringing together working groups composed of plant breeders, agronomists, nutritional biochemists, analytical chemists, and home economists, all of whom are working with legumes in developing countries, to ensure that plant breeders do not work in total isolation from and innocence of what the small farmer and the rural consumer want and are prepared to accept.

To reduce the unconscionable burden borne by the rural women of Africa and Asia, we have been supporting research and development of small village multipurpose mills capable of processing several different locally produced cereal grains and legumes into a form of flour or grits acceptable to local consumers. Projects of this kind are now in progress in West Africa, the Near East, Central America, India, and several countries of Southeast Asia.

In addition, because of the already stated difficulty of providing adequate fuel for cooking, IDRC is supporting throughout the semi-arid countries of Africa, a network of small-scale rural and village forestry projects each designed to select trees that will grow rapidly, that are comparatively drought resistant, and can be systematically harvested to provide the village communities with fuelwood, building poles, in addition to providing protection to crops and arable land against the searing desert winds and the incursion of the desert.

When invited to prepare this paper, it was suggested that mention be made of Canada's most useful future involvement in areas of activity related to the subject. Canadian government assistance can be conveniently classified under two headings, (1) food aid and (2) scientific and technical assistance.

Gifts of food grains and other agricultural produce are an essential and humane response to unforseen emergencies and disasters including extensive crop failures and major disruptions caused by natural or human violence. Of the latter, in the form of earthquakes, typhoons, floods, civil and military upheavels, there are probably about 12 a year in which some form of food and medical assistance may be required. I would urge that some thought be given to providing food in a form in which it can be used following disruptive disasters. I recall the sorry spectacle of Nigerian children, following the civil war several years ago, trying to eat raw flour which some well-meaning but mindless donor had sent to them as food aid. More sensibly

the Americans had sent an inexpensive slightly processed nutritious mixture of cereal, milk and soyflour which required only to be cooked in hot water for a few minutes and then was ready to eat. Wheat and flour are not much use to people whose mills and bakeries have been destroyed or irreparably disrupted.

Given the vagaries of the climate we must anticipate for many years that crop failures as a result of too little or too much rain will call for us to provide food aid. Food aid, however, should not be regarded as a universal panacea nor in any way a satisfactory alternative to increased agricultural production in developing countries. Consequently, our greatest support should be devoted to agricultural development and to improved food production, distribution and utilization systems in the least developed countries. We need to continue and to expand our support for the international agricultural research systems through the Consultative Group on International Agricultural Research and the International Agricultural Research Centres, and to expand and improve the national institutional and human resources devoted to agricultural development in the developing countries. This will call for a continuing increase in the funds allocated through CIDA and IDRC's budgets and also for a mechanism that will permit greater involvement by competent Canadians, particularly those employed in universities and the private sector, to make their contribution to international agricultural development. Among other wealthy countries, one finds

a variety of modalities by which their universities can engage in research and technical cooperation appropriate and relevant to the needs of developing countries. Some governments, from their international development budgets, provide additional staff positions in their nation's faculties of agriculture on the understanding that the number of scientists equivalent to the supernumerary positions are always available and on call for bilateral development projects. Other countries, alternatively or additionally, set aside a significant budget to support appropriate and relevant applied research in their own universities on carefully defined problems related to developing country needs.

In Canada we have no organized system by which to encourage a greater relevant participation by agriculturalists and food scientists in the international development process. Consequently in the future we should think not only in terms of the money we supply, but the extensive yet untapped source of Canadian professional manpower that is available and could be much expanded by thoughtful encouragement and cultivation.

I believe it was the Marquise de Deffano who wrote:

"La distance n'y fait rien, il n'y a que le premier pas qui coûte".

Canada's recent history of support for international agricultural development represents an important first step. There is yet a long distance to travel before we can view with satisfaction the state of nutritional well-being among our poorest neighbours.

If the distance between nutritional need and food supply is to be bridged during our lifetime, we must immediately move more swiftly, more imaginatively and more unselfishly in our support and encouragement for international food and agricultural research and development.

The views expressed in this paper are those of the author and not necessarily those of the International Development Research Centre.